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EDITORIAL

Electrochemistry of proton-conducting ceramic materials and cells

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Proton-conducting ceramic materials constitute an important basis for solid oxide systems that satisfy the "3E" criteria: economy, ecology, and efficiency. These materials allow electrochemical manipulation of hydrogen-containing components, thus facilitating not only processes of hydrogen detection, production, purification, and utilization but also more sophisticated applications, including pressurizing and electrochemical conversion (hydration/dehydration) processes. Achieving a rational combination of performance and efficiency along with long-term and redox stability requires an enhanced understanding of the properties of the particular materials used along with the corresponding electrochemical systems. In responding to this demand, the *Journal of Solid State Electrochemistry* has launched a special issue entitled "Electrochemistry of Proton-Conducting Ceramic Materials and Cells".

Although, more than twenty contributions to this special issue were expected, the current situation connected with the global COVID-19 pandemic resulted in the need to make certain adjustments. As a result, eight papers have been finally accepted for publication. These can be categorized into two main directions, the first connected with the synthesis and characterization of new proton-conducting electrolyte materials, while the second is focused on the design of suitable electrode materials.

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Within the electrolyte-related direction, a number of interesting results have been obtained not only for conventional perovskite-type materials but also for oxide systems having pyrochlore and layered structures. Satapathy et al. studied the $BaZr_{1-x}Ln_xO_{3-\delta}$ group of materials ($0.05 \leq x \leq 0.20$), presenting a comparative analysis of functional properties depending on the type of lanthanides (Ln = Dy or Sm). Their results show that Dy-doped $BaZrO_3$ can be considered as a promising electrolyte material, whose ionic conductivity exceeds the conductivity of Sm-doped counterparts by ~ 1 order of magnitude. A detailed analysis of the phase behavior of a ternary BaO–ZrO_2–Y_2O_3 oxide system was carried out by Ueno et al. This analysis provides a key for the preparation of both single-phase and highly dense $BaZr_{1-x}Y_xO_{3-\delta}$, otherwise representing a rather challenging task. In preparing the $Nd_2Zr_2O_7$ and $Nd_{1.95}Ca_{0.05}Zr_2O_{7-\delta}$ pyrochlore-type materials, Shlyakhtina et al. studied their phase structure, hydration features, microstructural properties, and electrical conductivity, as well as long-term stability over a period of 5 months. Tarasova et al. propose a new class of protonic conductors ($Ba_{1+x}La_{1-x}InO_{4-0.5x}$, where $0 \leq x \leq 0.15$) that exhibit a Ruddlesden-Popper structure, as well as presenting a detailed study of their transport properties.

In terms of the electrode-related direction, single-phase and composite materials have been prepared and comprehensively characterized in order to identify most promising candidates for use in protonic ceramic electrochemical cells. For example, the chemical compatibility and electrochemical activity of $La_2NiO_{4+\delta}$ electrodes were studied by Antonova et al. in order to apply them for systems based on a $La_{0.9}Sr_{0.1}ScO_{3-\delta}$ proton-conducting electrolyte. Tarutina et al. propose ferrites of the $Nd_{1-x}Ba_xFe_{0.9}M_{0.1}O_{3-\delta}$ family (where M = Cu or Ni, x = 0.4 or 0.6), which can serve not only as oxygen electrodes but also as fuel electrodes, allowing the adaptation of strategy of symmetrically organized electrodes for protonic ceramic electrochemical cells. Along with experimental results, Zhang et al. present a discussion of the theoretical basis for the electrochemical behavior of a $Sm_{0.5}Sr_{0.5}CoO_{3-\delta}$–$Ce_{0.8}Sm_{0.2}O_{2-\delta}$ composite electrodes used in $BaCe_{0.7}Zr_{0.1}Y_{0.2}O_{3-\delta}$-based solid oxide fuel cells. The work of Filonova et al. reports findings on new composites made of a misfit-layered phase ($Ca_3Co_4O_{9+\delta}$) mixed with a conventional perovskite phase of $BaCe_{0.5}Zr_{0.3}Y_{0.1}Yb_{0.1}O_{3-\delta}$.

Thus, this special issue represents a comprehensive account of recent achievements in the chemistry and electrochemistry of functional materials that form a basis for the fabrication of highly promising protonic ceramic electrochemical cells.

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